No. X.

LATHE FOR LENSES AND SPECULA.

The LARGE SILVER MEDAL *was presented to Mr.* CORNELIUS VARLEY, *1, Charles Street, Somers Town, for his Improved Lathe for Grinding and Polishing Large Lenses and Specula. The following communication has been received from Mr.* VARLEY *on the subject of his invention.*

NEARLY all the lenses or specula for the best optical purposes are ground and polished by hand, they requiring the constant and closest attention of a very skilful person to obtain perfection.

Some of the most eminent opticians have never used a mandril or lathe but for the purposes of rough grinding, to bring the lenses nearly to figure, and then they finished them at the post; and some, from habit and success, have acquired a prejudice in favour of the post, and are inclined to think they have more command of their work when there is no motion but what they give to it by their hands. Yet I think I shall shew that they may have most command when using a vertical mandril, one that may be easily regulated accurately to suit the work; and the operation will be performed much quicker, and by it much valuable time would be saved, which it is highly desirable to do, in order to obtain a larger produce from their talent, seeing there are so few who persevere to attain great perfection in the art.

I believe one reason why the vertical mandril has not been more generally adopted is, the difficulty of finding one suited to the optician's purpose, and free from objections. I will, therefore, state those objections, and then, in the same order, shew how I have removed them.

In the first place, emery or polishing stuff is always in use with this tool, and it is very liable to get into the fittings and wear them out, or, by spoiling them, make the lathe work very heavily.

Secondly, a very slow motion is needed for large work; to obtain which, with the requisite liveliness or speed of the fly-wheel, a small pulley must be attached to it: but this decreases the friction, by which it moves the band in those cases where the most friction is wanted to carry round the grinding or polishing tool; and if the band is tightened enough to give the wanted friction, the labour of moving the fly-wheel, and particularly the mandril, is greatly increased by the tight band so forcibly urging them towards each other, and against the collars and centres in which they run.

Thirdly, a heavy fly-wheel, from one to two hundred weight, is needed to overcome the resistance of the work. This cannot be stopped at the exact moment of need; and, if the work cleaves to the tool whilst in full motion, the operator is overcome, and damage is liable to occur.

Fourthly, a moving tool ought to run perfectly true; and, as the tools require to be turned on a horizontal mandril, when they are screwed on the vertical one they will not run quite true, for there are very few mandril-screws so true that what is turned on one will run true on the other.

Fifthly, when a workman first resolves to try his skill in polishing large speculums, he may be supposed not

to know what sort of tools will best suit his purpose until he has tried them; he therefore wishes to prove his skill with the least expense, and as he must have a horizontal lathe in which to turn his patterns and tools, the cheapest thing he can do is, to fix either a screw, or a screwed hole that corresponds with his mandril, on a post, and then he can begin his work; perhaps intending to have better tools when he has ascertained his wants, or when he can spare the price of them, not knowing that working at the post will retard his efforts, and that a vertical mandril would, by lessening the labour, facilitate his acquiring the requisite skill; for it is a fact, that most of those who are regularly trained to the business sink into mere tradesmen, while the greatest and most successful efforts have been made by those who had to find out the means of effecting their purpose.

The first objection, that of the emery soon spoiling the tool, my late uncle provided against by the means shewn in the section, fig. 1, and elevation, fig. 2, Plate III. *a a* is the steel collar-plate in which the neck of the mandril *b b* runs; it is let into and screwed tight to the board *c c* by the screws *d d*, which are put in from beneath, that nothing may stick up above. The hardened steel hole rises up around the mandril-neck about three-quarters of an inch; its taper, or enlargement, is upwards, so that the mandril *b* is put in from above. The face of the mandril around the screw is turned quite flat, and is purposely made much larger than the rest of the mandril, to afford a broad shoulder for supporting the chucks, but more particularly to receive the short brass or iron tube *e e*, which is screwed on by a fine thread round the circumference; it descends about half an inch below the top of the collar, so as to cover it like a cap, but

without touching it. This so well protects the collar and mandril, that no dust, emery, or water, ever gets to them, and the oil lasts much longer than in any common lathe. The mandril is lifted up about an inch, to apply oil to its neck; it is kept so clean as hardly ever to require wiping. A flat grinding tool *f* is shewn screwed on the mandril.

My uncle protected the bottom centre, or point of his mandrils, by the means I have here applied to the bottom of the fly-wheel axis *g*. It is turned quite cylindrical; and a short tube *h* is made to spring close, and slide tightly on it. The short tube *h* is, by means of a flanch, soldered to a larger piece of tube *i*; this covers the upper end of the screw *j* like a cap, and protects the oil. It is slid up to apply oil, and immediately down again to cover it; and as dust never rises in the air but only with it, and at a slower rate than the air, wherever an upward current is prevented, dust is also prevented; therefore, the cap being open downwards is of no consequence.

The second objection, a want of friction in the smaller pulley either way, I have very successfully removed by always using the whole circumference.

Fig. 3 is a top view of the vertical lathe: the board *c c* being removed, *k* is the fly-wheel, with three grooves or pulleys on it; *l* the mandril-pulleys. The large and small pulleys on each mutually correspond; and the increase on one equals the decrease on the other, so that the band fits any pair. Two additional pulleys *m* and *n* are used; their diameter equals the distance that the others are apart. These receive the band in its passage from one of the larger pulleys to the other; they are mounted in frames *o*, which have notches to vary their distance, in order to tighten or slacken the band.

Fig. 4 is a view of the band separate, to shew the manner in which it passes round the four pulleys.

Fig. 5 is an edge view of one pulley *k*, and half of the band, with the small pulleys *m* and *n*, to shew their sloping position of five degrees, or one inch in a foot, by which they cause the passing portions of the band to keep clear of each other, so as never to touch. The pulley-frames *o o* are fixed to plates *p p*: these plates have steady-pins *q q*, and fit the recesses *r r* in the braces *s s*; there being a pair of these recesses to correspond with each pair of larger pulleys.

By this arrangement the whole circumference of both pulleys is used, thereby obtaining all the friction; and the band may be made as tight as possible, without adding any friction either to the fly-wheel or mandril in their bearings. The pivots or points, whichever may be preferred, of the small pulleys *m* and *n*, are no stronger than the tightness of the band requires, and therefore the friction they add is too little to be worth noticing; whilst by their use the large collar and neck of the mandril is relieved from all friction but that occasioned by the work. With the usual tightness of band a motion can be obtained just as much slower as the whole circumference exceeds the portion formerly used; and a still slower motion, as the band may be used much tighter than by the old method, because its tightness never affects the mandril or fly-wheel. Therefore, a pulley so much smaller may be put on the fly-wheel. But we cannot follow this reduction by any farther increase of the mandril-pulley, because that would remove the operator too far from his work; therefore the space must either be filled by larger pulleys *n* and *o*, or the fly-wheel be mounted in a frame, as fig. 6, so as to be movable to or from the

mandril, or by enlarging the framing. The pulleys *m* and *n* may be placed aside, as shewn at the horizontal lathe, fig. 7.

Thirdly, the momentum of the lathe continuing while the work requires to be stopped, is obviated by mounting the pulley *n* on springs, but not the other, and adjusting the tightness of the band to just the right degree, and no more; the operator may then stop the mandril by his exertion on the work, and the springing pulley will give way enough to let the wheel go round without carrying the mandril. The simplest mode of effecting this purpose with the horizontal lathe is, instead of supporting the upper pulley *v*, which answers to the pulley *n* in the former figures, by its rod *t*, which is bound at a suitable height by the screw *u*, to let go that screw and support it by the lever *w w*, which may be attached to the rod *t* by its binding-screw *x*; the other end of this lever *w* having three or four notches to rest in, at the most convenient place for the workman to reach; the fulcrum of the lever being in the middle, and supported from the back of the lathe. When the handle *w* is pushed out of its notch, it flies up, and the stop *x* being rightly adjusted, allows the pulley *v* to descend enough to slacken the band, but not to make it loose enough to run off the pulleys. The mandril or work may then be held by the hand; and by replacing the lever in the first, second, or other notch, the required tightness is immediately restored; and the fly-wheel being kept going, the work proceeds without loss of time.

Fourthly, to obtain perfect truth in the tools, I have adapted to my purpose a method of governing the end or longitudinal shake of the mandril, entirely at the back centre. I make the head of a horizontal lathe, fig. 7, to

receive the same vertical mandril *b b*, of figs. 1, 2, and 3; and as this mandril is put into its place through the collar *a*, it requires a different arrangement to that in common use for governing the end-shake; and this I do entirely at the back centre, on a similar principle to that described by Mr. J. Clement, in Vol. XLVI. of the Society's Transactions, but simplified and combined with other requisites for this particular use. Instead of covering the back centre like the fly-wheel centre in fig. 2, by the cap *h i*, I leave a solid flanch *y* at the bottom end of the mandril *b b*, fig. 1, and screw on to it a tube *z*, to form the cap which protects the oil. In figs. 7 and 8 it is shewn without the tube *z*, though it is well to use it there also. 1 1 is the poppet, to which the mandril is held by the clamp 2 2 embracing it and the flanch *y*; and the end-shake is correctly adjusted by the screw 3. Two screws 4 4 hold the clamp 2 to the poppet standard. Fig. 9 is a top view, and fig. 10 an end view of this clamp, to shew how it fits round the flanch *y* of the mandril. To adjust the mandril so as only to move easily in the collar *a*, the two screws 4 4 are slightly loosened, to let the clamp slide under them; then, on turning the upper screw 5, it will move the clamp, the poppet, and the mandril, all together, and bring it to fit the collar; the screws 4 4 are then tightened, to keep it there, and the nut on the screw 6, fig. 9, is turned to bind the poppet fast. The body of this screw is square, as shewn at 6, fig. 7, and the poppet passes through it. The mandril, when placed vertical, keeps in place by its own weight, without the clamp 2; but as a safeguard, to prevent its being lifted up with the tools or work, an iron button 7 7, fig. 7, is placed near it, so as to be turned over the flanch *y* without touching; and a pin 8 keeps it from shaking aside.

Thus the same mandril fitting both lathes, the work will always run true. In figs. 1 and 7 are shewn screws 9 9, which must be withdrawn to let the pulleys *l* slip off, when the mandril is to be taken from one lathe to the other.

In the top view, fig. 8, a screw 12 is used instead of the poppet 1, and a clamp 10 screws on and confines the mandril to it: the screw 11, fig. 11, binds it fast when properly adjusted; it will then turn round with the large screw 12, by which the mandril neck is to be adjusted to suit the collar. The nut 13 serves to bind the screw 12. The horizontal lathe is fitted with another mandril similar to the first, for all ordinary work; the vertical mandril is only put in for turning its own tools.

Having for many years experienced the benefit of using the whole circumference of the pulleys, I have, in figs. 7 and 8, shewn how extra pulleys are adapted to the horizontal lathe. 14 is the lower pulley; its frame is made to turn round in any direction, by the screw and collet 15; and by the screw 16 fitting different holes in the board 17, it may be moved to suit any groove in the fly-wheel *k*. The frame of the upper pulley *v* is made to turn round in the spring 18, and this spring can slide under its binding-screw 19, to be placed over the other grooves. The spring 18 is mounted on a rod *t*, which slides in the tube 20: *u* is a binding-screw to fix the rod *t* at any height, and thereby give any required tightness to the band: *x* is a stop, which, by being bound fast to the rod *t*, enables the screw *u* to be loosened in order to lower the rod any measured degree, and thereby very gently to slacken the band to suit the work, either with or without the lever *w w*; for in many cases it is desirable that the band should slip, rather than break a delicate tool, or spoil the work, or

break off that which is only cemented on. The tube 20 is attached to the lathe by the arm 21. The swivel motion given to the small pulleys *v* and 14 enables them to correspond with the mandril pulley and fly-wheel on one side, and with themselves on the other. I do not only adopt the method of governing the end-shake for this particular purpose, but I prefer it for all large mandrils, because the friction may be much less by it than by letting the whole circumference of the large mandril be wedged into its collar, and it admits of a stronger screw in proportion to the neck, with a solid shoulder of any required size, by which wooden chucks are so well supported, that if they are frequently taken off, they will again go on true, and the driving work into them by a mallet will not put them out of truth. I make a portion of the hole in the collar *a*, both at top and bottom, a little wider than the neck of the mandril, as shewn at 22 22, that it may hold oil, and gradually supply the fitting portion by capillary attraction, and not let the oil run down the mandril. I make the bottom centre or point of hardened steel; the upper part of it fits nicely into a taper hole in the mandril, as shewn in fig. 1, and I put a hardened steel plug into the screw to receive it; the steel point is of a longer cone than the hole in the plug, so that it only touches at the bottom; this lessens the friction, and gives room for the oil to draw in by capillary attraction. By separating these centres from the mandril, they can very easily be repaired, and therefore may always be kept in good order.

I have used twine as much as gut for the small lathe-bands. I splice the ends together, and smooth it with a cement of wax, resin, and whiting, in equal parts, and then wax the string, and it runs as smooth as gut.

For the large lathes I use the plaited patent sash-line ; it is very soft and flexible, and has no tendency to twist. I first bind the ends tight with iron binding-wire, and then join them together with a steel wire hook, as shewn (half the real size) in fig. 12 ; fig. 13 is the hook separate. In cases where the band requires frequently to be unhooked, to take on or off, I use two hooks, though I prefer the single hook, because with it the ends of the band may be brought so close as to keep up the continuity or full size of the band, for it is bad to have any one part of the band smaller or larger than another; and I use steel wire, because it gives, with the requisite strength, the thinnest possible hook. I make them very smooth, and taper the ends, to remove all that does not contribute to their strength, and bend the points inwards, to prevent catching. These joints, when well made, are nearly as durable as the band.

In fig. 2, 23 23 is part of a circular ridge to confine the droppings of the tool to that part of the board, the front half being sectioned off to shew the mandril cap; it should not be as high as the collar, that it may never hold water enough to run over to the mandril; but there should be a hole in some convenient part, to let the water run into a vessel supported under it. In figs. 2 and 3, 24 is a roller to support the crank-wire 25; 26 is a pulley, over which the line 27 depends to the treadle 28; 29 is a seat attached by the hinge 30; at 31 and 32 are the hinges which join the prop: these three hinges have loose pins (one is shewn separate at 33), so that by pulling them out the seat and prop may be removed. I find this seat a great convenience; it connects the weight of the operator to the tool, so that all his exertions are neutralised as regards any strain or springing of the frames, and it forms

a fulcrum from which the treadle is moved with less agitation of the body.

In fig. 1, the screw-head on which the mandril stands has shallow holes 34, by which to turn it round for adjustment; into one of them the stud 35 of the nag's-head lever, fig. 14, enters.

Having now described the vertical lathe, it remains to shew the advantage which a moving tool has over a stationary one.

A flat tool will serve to illustrate its action; it may be operating on a block, as fig. 15, or on one flat surface, either of glass or speculum-metal, figs. 16, 17, and 18. A grinding tool should be so much softer than the glass or speculum to be worked, that the emery will stick into it with the pressure requisite to make the emery cut either the glass or speculum, and the coarser the emery, the softer should the tool be. Type metal (which is lead hardened by melting a portion of antimony with it) makes a very good tool for coarse emery, but brass is best for the finer emery. If glass is ground on glass, they must both be of the same size; and if tools are ground together, it is best for them to be of the same size; three equal-sized tools ground successively together will become flat, for if two were at first concave, when ground together they would become flat, all but the excess of one concave over the other, and that excess would make the other a little convex; then if the third was convex, those two would correct each other, all but the excess of one; and out of three there must always be two with similar faults to correct each other: thus, by regularly changing them, there is a constant approach to similarity in the three, and that must be flatness.

Grinding tools being always softer than the work, are

less acted on by the emery, and should be larger in diameter than the work; if the tool is no bigger than the glass or block, the weight of the latter, when it overhangs, as in figs. 16 and 17, will be all on the central parts of the glass, as at 36, and on a part of the circumference of the tool; this tends to grind the work concave and the tool convex; but let the tool be half as wide again as the work, like figs. 15 and 18, there will be no necessity for the work to overhang more than enough to secure an equal action on the tool; for here, the circumference being greater, is less covered by the work; and yet the centre being almost always covered, may be worked hollow instead of convex; therefore, whatever concavity may be induced in the work when it overhangs, will be counteracted when it comes over the centre. This alternate tendency is an evil that cannot be avoided, therefore the man that can so correctly balance them as to produce perfect work, must possess abilities that entitle him to praise; for the first proof a workman can give of his fitness, is by keeping his tools in good order, and wearing them all over so equally as not to vary from their original figure.

If the tool is fixed, the operator sometimes carries the work over it in right lines, as in fig. 19, beginning at one side 37, and ending at the other 38; he then changes his position a few degrees, and works back again to the other side, and thus he keeps stepping round the tool, and occasionally mixes or alternates a circular or cycloidal motion equally over the tool, as in fig. 20, where the line 39 shews the passage of the centre of the work over the tool; and he keeps turning the work round in his hand a few degrees each time. Here there is no work done but at the expense of much muscular exertion, and it requires an almost slavish closeness of attention to secure uniformity

of action. But let the tool revolve, and the laws of motion immediately become his servants, and assist in securing uniformity. When he carried his work in right lines over the fixed tool, the scratches or grain became straight; but this same motion over a revolving tool produces a curved grain, and no two of these numerous minute scratches are in the same direction, but they all cross each other, so as to produce equality; then, instead of a slavish attention to change the angle of his work, he only gives way to the tendency which the tool has to cause a slower revolution in the work, and he may more conveniently put suitable weight on his work: thus there is a great increase of speed in the operation, for, instead of having all to do by himself, his chief attention is to govern what is almost done for him. Then he avoids the fatigue of carrying himself round the tool, and may sit to his work whenever it is eligible, thus relieving himself of much useless fatigue.

By mixing the regular circular motion of the tool with the right line or cycloidal motion of the work, an enormous increase of the directions or ways in which the work and tool pass each other is obtained, and with it so much quicker is the desired effect produced. Again, this vertical lathe admits of a motion so slow when the workman wishes it, as to be little more than the rate at which he would step round a fixed tool; and even this is less fatiguing and better than stepping round, because the equal motion of his foot at the treadle induces an equal motion of his hands in moving the work. But the great advantage of the revolving tool is, that full speed may be used to bring the work near to a finish, and then slackened, to suit more accurately the powers of the operator. Lenses are to be polished on bee's-wax, hardened by the polishing stuff (oxide of iron), as stated in Vol. XLVIII.; but speculums

are polished on pitch, with oxide of tin and water: in hot weather it is hardened by a portion of resin; in very cold weather, pitch alone may do, though there is so much difference that experience is the best judge of the suitable hardness; for pitch that is too hard at first, will acquire so much warmth during its use as to become quite soft enough, therefore there must be little intermission, lest it cool again, but the work must be continued till complete. If these tools are at first warmed as much as the working can keep up, they act best. Great care is requisite to have pitch and resin that is quite free from grit, or any thing that can scratch or render it unequal; and they should always be covered close when out of use. In case the pitch and resin should be too brittle, linseed-oil is the best substance by which to lower it to a proper consistence. The alloy of which speculums are made being very brittle, is liable to break up, instead of being cut by the emery, therefore, after smoothing as much as possible with fine emery and water, on brass tools, the speculums are still more perfectly smoothed on the best foreign blue-stone, or very fine slate, turned true, and ground flat, or to the right curve; it is kept wet, and when the speculum is nearly finished, it is kept from drying or sticking to the tool by moistening it from the mouth: this tool never breaks up the surface of good metal, but brings it almost to a polish, and preserves the figure. In this state it reflects light enough to be tried as to figure.

The method of trying a flat surface, is to direct and adjust a telescope to some convenient distant object that is sharp and well defined (a chimney-pot answers the purpose well), and then lay the speculum level or only a little inclined, so as to reflect the same object very obliquely; then look at this image through the telescope, and if it is

well defined, the speculum is flat; but if the tops or bottoms of objects are burred, somewhat like a reflection in rippled water, it is not flat; to know whether it is convex or concave, place the metal nearly opposite the object, to reflect it as nearly direct as it can be viewed, and look at the image through the telescope; then, if the telescope requires shortening to obtain distinct vision, the speculum is concave; but if it requires pulling out, the speculum is convex; and the quantity that it is requisite to shorten or lengthen the telescope gives, by proportion to its own focus, the quantity of the concavity or convexity, when that knowledge is of any consequence.

After the speculum is well smoothed on the slate, it requires but little time to polish it on the pitch-tool, if that is in good order; and it is of great consequence that it be so, as long working on the pitch is in danger of altering the true figure, for the pitch acquires a softness that yields and cleaves to the speculum; and by the pressure of the work it is liable to spread out a little during the process.

It is also of great consequence that the polishing tool be perfectly true in every particular; first, that the iron or metal chuck or plate on which the pitch is placed be quite true, and correspond correctly with the face of the speculum to be polished, so that the pitch may be every where equal in thickness between them, yet uniformly rough, the better to hold the pitch; next, that the pitch be turned quite true or circular; thirdly, that it be quite clean, and free from filaments, grit, or lumps, or any thing that can scratch or produce irregularity in its yielding or cleaving to the surface which it is polishing. The thickness of pitch may be from one quarter to half an inch; if it is too thick, it will yield too much, and be liable to get

out of figure; if it is too thin, it will not be able to yield as much as the work requires. If the pitch is deficient on one side, the efforts of uniform working will sink that side most, and put the tool out of figure. If one side is redundant, by being thicker, or if it projects out from the circle, it will not sink or yield uniformly with the rest; and if that part is more worked on to sink it, that will act unequally on the speculum, and put it out of figure.

In managing a grinding or polishing tool, great care is requisite to keep the tool in figure. If the work is kept on the tool always within the circumference, it is itself safest from accident or scratches, but the tool will be sure to work out of figure. Therefore the work must be made uniformly to overhang, as in figs. 15 and 18, on all sides, to work down the circumference of the tool; but the circumference possessing the most grinding surface requires more working on upon that account; and when the work overhangs, there is a portion of its circumference not being acted on, and its weight is causing a stronger action on the central parts. Thus, when we take care of the tool, the work is in hazard, and if we regard only the work, the tool will go out of figure. These evils are much greater with flat work than with spherical; for any deviation, however true, will spoil that which is intended to be flat; but in spherical work, a little deviation, provided it is true, may be of no consequence, as it will only increase or decrease the length of focus; hence careful workmen mostly prefer a curve of long radius instead of a flat, when it will answer their purpose. By a little consideration of these evils, it will be seen that close attention and skill are requisite to produce perfect work.

Speculum metal is made with two parts of copper to

one of tin, with slight variations or additions of other metal, such as arsenic, zinc, silver, or platina.

When the true saturating proportions of tin and copper are obtained, the metal is perfect, but too brittle to be used of any considerable size. When copper predominates the metal is very strong, and will receive an excellent polish, but will soon tarnish.

If tin predominates a little, the metal becomes beautifully white, and will not tarnish, but it greatly loses strength and toughness; it therefore breaks up while grinding, instead of being cut by the emery, and is very difficult to smooth on that account, for even then it is liable to a fine breaking up of the surface, that looks like pores.

The melting heat of copper is higher than that of the compound; and, when it predominates, the excess of copper is the first that sets, and then the brittle compound sets around it; and as the brittle metal has to contract more in becoming solid than the copper, which is already set (if we may suppose that precedence to take place), it can do so on the tough copper, and only increase its hardness, therefore the alloy remains very strong and tough. But as tin, in all proportions short of saturation, strengthens copper, it is probable that the copper holds all such portions in true and equal solution. Not so the tin; it has no such power on the copper; for the over-dose sometimes oozes out at the time of setting, and is quite soft, and the compound setting in liquid tin is liable to assume a crystallised texture, which is distinctly seen while smoothing.

When the tin predominates, the portion of this which saturates the copper composes an alloy which sets like a brittle sponge filled with liquid tin; this latter remains fluid a long while after the compound has set and has

contracted; and if the tin has been so much in excess as to preserve the continuity of pores open to the surface, the contraction of the compound will squeeze out a portion of the excess of tin in studs of all sizes; but what is locked in resists the natural contraction of the brittle compound, which we might, therefore, expect to be pulverised, but the effect is to make it appear rotten, for it breaks up by the action of the emery, instead of being cut. Afterwards the tin sets, and in so doing would contract at a greater rate than the compound; this it cannot do, and, consequently, remains in a state of tension, hich, when subjected to grinding, causes it to break up before the emery, rather than be cut away, and thus exhibits a texture coarser than is due to the emery.

Now, the desideratum is to over-dose the neutral or saturated compound of tin and copper with some tough and white metal that will not tarnish, and whose melting heat is greater than the speculum-metal, in order to give toughness and strength to be easily worked. Silver, iron, or platina, in very small quantities, might probably produce the desired effect; some of these have been used, but not with reference to this particular purpose. A small portion of zinc prevents the metal from tarnishing, but it requires great care to preserve the metal from being porous. The effect of rottenness is liable to occur whenever a brittle compound is let down by soft or weaker metal of a lower fusing point.

Such rotten brittle metal of course requires much more working on the pitch to polish out the breakings; and when a brilliant surface is obtained, it is a serious thing if it prove not flat, which it is liable to from the length of time that it was on the pitch; for the quickest mode to obtain flatness is to re-smooth, but in so doing it would

lose that sound surface, the obtaining of which endangered its flatness. With such metal I had a strong proof of the benefit of a revolving tool. Having to repolish a speculum, the surface of which was excellent, the person in whose hand I put it could obtain a very good polish, but could not preserve its flatness ; it was, therefore, often resmoothed to regain a flat face. This at last took off all the excellent outside crust, and the remainder broke up, even on the slate-tool, so as to appear as if full of pores ; but finding that with much polishing these disappeared, and a good polished surface, not distinguishable from the former, was obtained, I would not again lose that surface, but determined to polish it flat. I therefore tried what figure it was, by the method previously stated, and found it concave. I then turned a polishing tool strictly true, and of such a size as I knew by experience could be governed by the metal : I next worked the metal as a spherical one whose focus I wished to lengthen, taking care to preserve truth of figure, and trying it regularly to see at what rate I was reducing the sphere ; and by this process I carried it on uniformly to flatness, so good as to bear the strictest trial by a two-foot achromatic telescope. I caused the tool to revolve as quick as I could manage it, as I have found the figure of the tools to be best governed with a quick motion ; and I am quite sure I should have been four times as long with a stationary tool, and probably very much out of patience with so tedious a task.

I have mentioned an excellent crust or outside : that is another reason for wishing to remove the extreme brittleness by some hard and tough metal which will increase its strength ; for then the metal could be cast in cooler moulds without cracking, as, the quicker the outside can

be allowed to set, so much thicker, harder, and more compact, will the outside crust become. Therefore, it is desirable to cast with the face downwards, and obtain the truest and soundest face possible, that we may grind and polish without working through this crust.

If metal that is liable to prove porous is cast in iron moulds that do not fit close, the thin fins of metal that run between and cool quick will break with a glassy fracture, while the thicker mass will not; and the thin fins are easier polished, shewing no pores, while the thicker mass will have pores.

I have mentioned brass as being preferred for fine emery, and slate or blue-stone for smoothing; yet Mr. Tully, whose skill in working speculums has never been surpassed, informs me that he has smoothed most successfully on lead with very finely washed emery: specimens of this smoothing I have seen, and it certainly was very good. This is a valuable addition to the smoothing tools, because slate that has an excellent tooth or grain for smoothing is very liable to have a crooked or wavy grain; some slate-tools of mine have very small convexities in the grain, that look like knots in wood. These do not appear to differ in their texture from the other parts, but they would not work down as fast as the more even layers, and therefore if much used, the work will be spoiled. To prevent them from doing mischief, I have been obliged to scrape them down a very little below the surface, and then I could keep the tool flat. I have also had tools made by combining pieces of foreign blue-stone; these had a similar fault, which made me abandon them, and use slate; for though they look very homogeneal and alike, they are liable either to differ a little in hardness, or not to have the layers of the different pieces perfectly parallel with each other; and

therefore, from some such cause, the sides of some pieces would always work down faster than the neighbouring sides of the next pieces. This I repeatedly proved by giving them one or two rubs on a flat grinding tool, which would scratch all the higher parts, and not touch those that had been worked down below the general surface.

I have also used successfully a very perfect flat grinding tool, so well paved with fine emery as to cut well with hardly any loose emery about it, in order to discover the imperfections of work executed in a common turning lathe. There are therefore two reasons why work intended to be flat will not prove so, although it has been turned with a true slide or swing-rest so accurately set that the cutter will touch the surface equally at opposite sides of the axis, as at 40 and 41, in fig. 21.

A tool will cut metal best with a moderately slow motion; and supposing this good speed occurs near the centre, as the tool proceeds to the circumference, the velocity with which the metal passes the tool increases exactly as its distance from the centre does. This may be carried to such an extent that the sharpest cutting tool will be beat away without being able to cut; hence, when a tool passes in a right line across the face of the work, it will make a full cut at the centre, and this will lessen gradually as it approaches the circumference, where it may not be able to cut; the work will therefore be hollow, and this hollowness will be still deeper from the violent action of the tool against the work causing both to spring from each other. This fault Mr. Clement has very successfully removed, and received the Society's medal for so doing (see Vol. XLVI.); but still this fault is allowed to remain with all ordinary lathes. The next fault is dependent on the shape and strength of the mandril; and I do not recollect ever seeing a large

mandril whose thickness was sufficient to support metal plates (of the largest diameter the lathe could take in) well against the tool; they will all spring or bend, and thereby allow the work to retreat from the tool when it is cutting near the circumference: the difference in the growl and size of the waves or vibrations marked on the surface by the cutting tool shews it. So long as, from false economy, mandrils are made too weak, they ought to be kept perfectly round and true, to equalise their springing; and in all cases, let them be ever so strong, they ought to be round, and not square. Fig. 21 shews the kind of surface produced on a square mandril that was weak enough to spring. On applying a straight edge across the centre, to see if the work was flat, it appeared hollow in some directions and convex in others. I therefore ground it a very little on the fin· flat tool, and it shewed the two cross hollows, 42, 43: these corresponded so correctly with the angles of the mandril, that they exhibited the same imperfections which existed in the square of the mandril, and I was able to say which hollow corresponded with a given angle of the mandril; and it proved to be so when I screwed it on again. These hollows are occasioned by the mandril being stronger across the angles; therefore, when they correspond with the tool, the work is better supported and the cut is deeper; those parts, as 40 41, which corresponded with the thinnest sections of the mandril, sprung most away from the tool, and were the least cut.

Fig. 22 shews the kind of figure that is liable to occur when endeavouring to turn a cylinder on a square mandril.

I have two lathes in which the band goes round under the fly-wheel in the usual manner; the grooves are wood, and V-shaped. These bands go quite round the mandril-

pulleys, in which the grooves are also wood, and wide, like those of figs. 7 and 8, and then pass upwards to pulleys mounted like *v*, fig. 7. The quantity or length of the fly-wheel's circumference which the bands engage is just double the length of the whole circumference of the mandril-pulley; and yet these small mandril-pulleys hold their bands so tight that they will slip round the fly-wheels, and not round the mandril-pulleys. This fact is in favour of the open or wide grooves, and against the V-shaped ones, and certainly in favour of using the whole circumference.

In fig. 7, the fly-wheel axis is shewn as running on a single friction-roller at each end, and is kept in place by passing between loosely-fitting upright pins or forks.

No. XI.

STAGE FOR A MICROSCOPE.

The SILVER ISIS MEDAL was presented to Mr. EDMUND TURRELL, 46, Clarendon Street, Somers Town, for his Improved Stage for a Microscope. The following communication has been received from Mr. TURRELL on the subject of his invention.

46, *Clarendon Street, Somers Town,*
SIR, *Feb.* 14*th*, 1832.

THE great attention that has been lately bestowed upon the microscope, in order to bring it to the greatest degree of perfection, renders any apology from me unneces-